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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

The Two-Cycle Oil Engine

Its Lubrication and Operation

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS

Recommendations for Lubrication of the Two-Cycle Oil Engine

BELOW we give a suggestive list of Texaco Lubricants for the general lubrication of the Two-Cycle Oil Engine. A judicious use of these recommendations will make possible the right choice of the right oil, according to the type of oiling system involved. These lubricants can be promptly supplied through the many Texaco Stations scattered throughout the country.

Where the Same Oil is used throughout the Engine	*TEXACO URSA OIL or TEXACO TEXOL OILS
Where Separate Oils are required for Individual Parts	
Cylinders:	TEXACO Ursa Oil or TEXACO Texol Oil X
Bearings:	
Force Feed Lubricated	TEXACO Alcaid Oil or TEXACO Texol Oil C
Splash Lubricated	TEXACO Regal Oil or TEXACO Texol Oil B
Ring, Chain or Oil Cup Lubricated	TEXACO Alcaid Oil or TEXACO Texol Oil C
Air Compressors:	
High Pressure	TEXACO Ursa Oil or TEXACO Texol Oils as recommended
Low Pressure	TEXACO Algol Oil or TEXACO Alcaid Oil or TEXACO Texol Oils as recommended

Special Condition

Where moisture may be present in cylinders as in water injection types of engines use Texaco Texol Oils as recommended.

*Note.—While this oil will, in general, best serve the intended purpose, it must be remembered that certain types of engines may require oils of somewhat lower viscosity, therefore it is advisable to consult with the manufacturers wherever possible, in order to obtain their recommendations in this regard.

THE TEXAS COMPANY, U. S. A.

Texaco Petroleum Products

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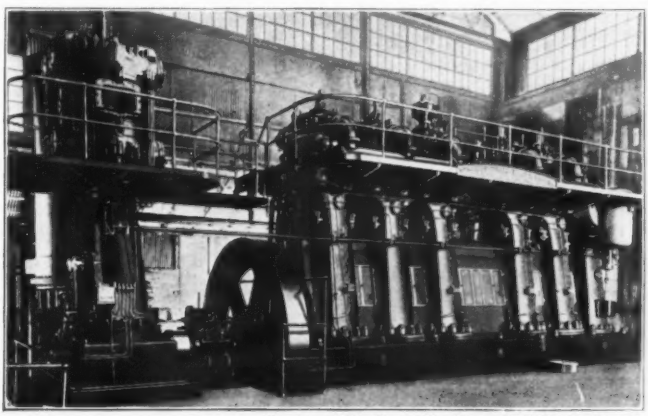


Courtesy of Nordberg Mfg. Co. and Oil Engine Power.

Fig. 1.—A two-cycle Diesel Engine connected to an air compressor. The relative size of these two machines is clearly brought out.

The Two-Cycle Oil Engine

Its Lubrication and Operation

IN the development of power generation equipment, especially as adapted to the operation of such machinery as electrical generators, compressors, ice machines, etc., in stationary practice, and for the propulsion of ships and driving marine auxiliaries, the oil engine has been especially prominent. In fact, in the marine field, according to a current survey, constructional work on motorships recently commenced exceeded that on steamships by a slight margin.

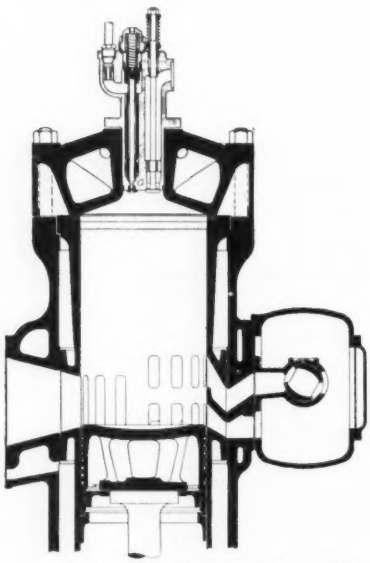
Within the range of power capacities required, the two-cycle type of engine has proven to be extremely economical from both the viewpoints of installation and operating costs. Just as an example, it is interesting to note that the average fuel consumption ranges in the neighborhood of 0.45 lbs. per brake horse power hour, while the lubricating oil consumption is approximately one gallon per 1,500 to 2,000 horse power hours, or even better according to some manufacturers.

The efficiency of the two-cycle oil engine is in general dependent upon such factors as:

(a) The fuel and its manner of combustion;

(b) The lubricants and their application;

(c) The cooling water and the extent to which it brings about reduction in cylinder temperatures.



Courtesy of Busch-Sulzer Bros. Diesel Engine Co.

Fig. 2.—Sectional view of the cylinder of a two-cycle engine, showing the scavenging system. Note simplicity and rigidity of construction.

(d) The extent to which the design has been perfected.

All these individually or collectively, if in any way unsuited to the engine or operating conditions, will cause a marked decrease in the ultimate power and efficiency which will be developed. Before we can discuss them in a comprehensive manner however, a word of explanation concerning the operating principles involved, will be of interest.

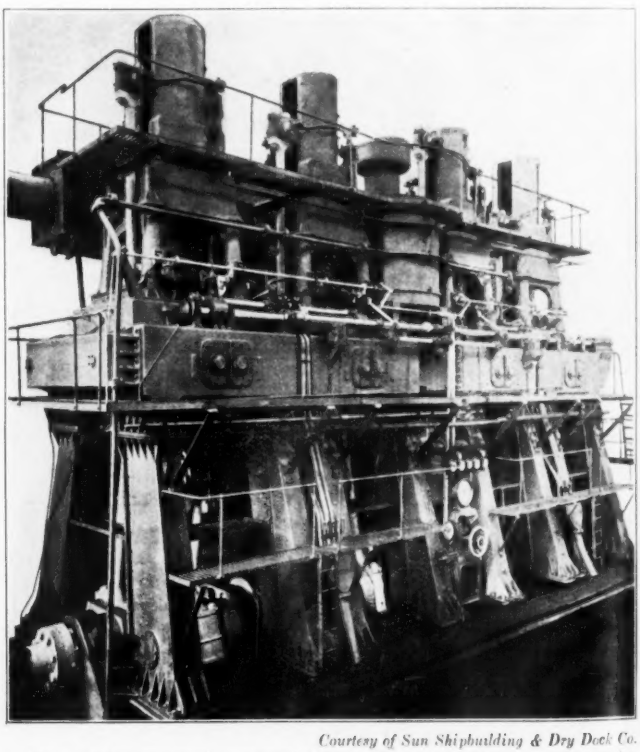
DESCRIPTION

In the two-stroke cycle engine, the four essential stages of a single cycle which the fuel must undergo in its passage through the engine, viz.: suction or admission, compression, explosion and expansion, and exhaust, take place over two strokes of the piston or during one complete revolution of the crank. As a result the number of power strokes per revolution in an engine of this type will be the same as the number of cylinders. Essentially there is no theoretical difference between the four-cycle and two-cycle principles of power development. In the two-cycle engine but two strokes are necessary to complete a cycle for the reason that the pistons themselves function as exhaust valves. Therefore, with the completion of the exhaust stroke, fresh air is blown into the cylinders from an outside source, thus eliminating the necessity for exhaust and suction strokes. In some engines of this type the base of the machine functions as a compressor on the down stroke of the piston. In a two-cycle engine twice as many power strokes result in a given number of revolutions; in consequence, theoretically, twice as much power should be developed in event of each impulse being as great as its corresponding impulse in a four-cycle engine.

A comparison of the two-cycle engine with any other type of oil engine from the viewpoint of its advantages and disadvantages is out of place in an article of this nature, inasmuch as there is such an extensive difference of opinion concerning their relative importance. It is sufficient to say that the use of either a two or a four-cycle oil engine will depend largely upon the purpose to which it is to be put, and the operating conditions involved.

THE FUEL AND ITS MANNER OF COMBUSTION

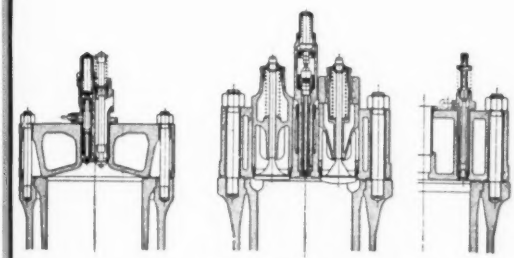
Fuel is injected into the oil engine either alone as in the solid injection type of en-



Courtesy of Sun Shipbuilding & Dry Dock Co.

Fig. 3.—Side elevation of an opposed-piston type, two-cycle oil engine. This engine is distinctive for the absence of valves; its direct reversibility, and the equalization of stresses and strains of operation.

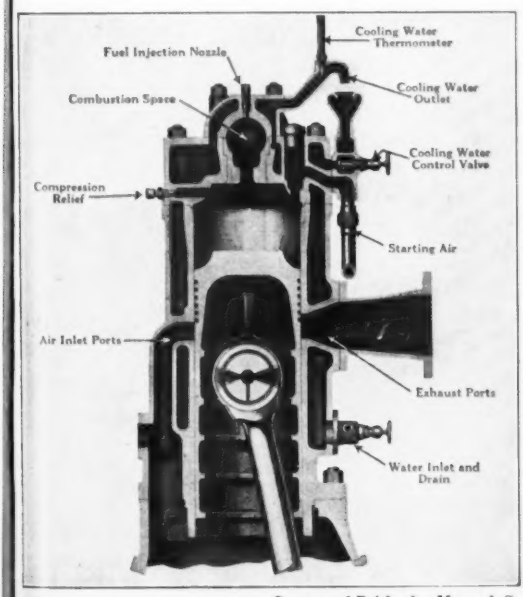
gine, or in company with an atomizing agent such as compressed air. Water injection along with the fuel, or early in the compression stroke, is also used in some surface ignition or semi-Diesel engines. Its chief advantage is under heavy loads, where, in general, it will cause smoother running due to vaporiza-



Courtesy of Busch-Sulzer Bros. Diesel Engine Co.

Fig. 4.—Comparison of cylinder heads and valves of representative two and four-cycle oil engines. Note the simplicity of the two-cycle type as brought out by the left-hand sketch.

tion, the resultant reduction in temperatures, the maintenance of a more constant temperature of the hot bulb or plate, and a certain decrease in the intensity of the explosion which this brings about. While it may be admitted along with the oil, water does not serve to

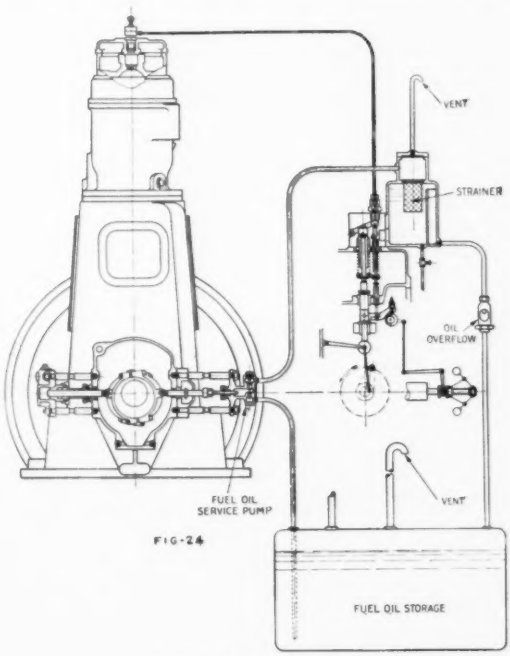


Courtesy of Fairbanks, Morse & Co.

Fig. 5.—Transverse section through the cylinder of a valveless two-cycle cold starting Diesel type oil engine. Note provisions for cooling water circulation.

inject the fuel. In marine practice especially it is most important to use fresh water for this purpose, due to the corrosive effects on the cylinder walls which would otherwise be brought about. In fact water injection is regarded with disfavor by most marine engineers for this very reason. Furthermore, there would be excellent opportunity for the formation of sulphuric acid in event of using fuels of high sulphur content, due to the reaction of water and sulphur. The ultimate result would be the corrosion of engine parts, especially those adjacent to the exhaust.

The earlier Diesel plans called for charging of the fuel alone. Later, however, it was developed that compressed air was a decidedly effective means of atomizing the oil sufficiently to bring about instantaneous combustion. The extent to which this air should be com-



Courtesy of Worthington Pump & Machinery Corp.

Fig. 6.—Diagram showing system of fuel distribution to a two-cycle oil engine. The relative location of the storage tank, piping, oil strainer, pump and engine, is clearly brought out.

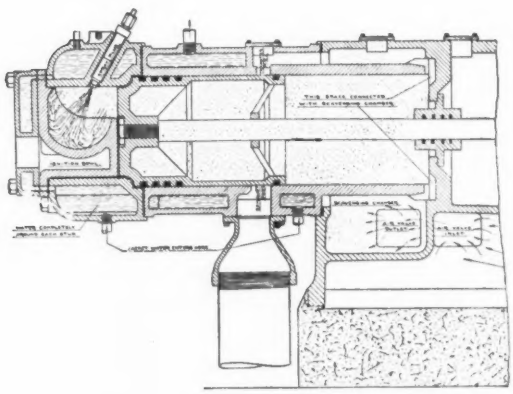
pressed was found to depend upon the grade and viscosity of the fuel oil, the load carried by the engine and the design and construction of the atomizing equipment. On the other hand, high pressure air systems as are involved on oil engines of the air-injection type are costly and intricate. Where smaller types of such engines are necessary, it can, therefore, be readily appreciated that the use of air might oftentimes easily become a matter of impossibility; this is due especially to the practical necessity for simplicity in view of labor conditions.

The smaller two-cycle oil engine as a result has developed essentially into a solid injection type of engine although both water and air are

of course used to some extent. In larger engines of this type air injection is extensively used.

In operation, the fuel is handled in one of three ways, viz.: it is:

(a) Pumped into the engine under suitable pressure, or perhaps atomized by compressed air, combustion being brought about by virtue of the hot compressed air within the combustion chamber.



Courtesy of The Buckeye Machine Co.

Fig. 7.—Section through the cylinder of an horizontal two-cycle oil engine at ignition, showing spray of fuel entering the ignition bowl. Note provisions for cooling the cylinder and the location of air outlet and inlet in lower right-hand corner.

(b) Injected into the combustion chamber to impinge upon some externally heated surface, which latter serves to heat the combustion chamber sufficiently to insure firing of the charge at the proper time. Certain two-cycle oil engines only require this during the period of starting. After that, combustion is maintained by virtue of the temperature and pressure to which the air is raised, or

(c) A charge of fuel is accumulated in a suitable cup adjacent to the fuel valve on the suction stroke. Near the end of the compression stroke the inrush of highly heated air which is provided for, serves to volatilize enough of this fuel charge to bring about combustion, which reaction forces the remainder of the fuel into the cylinder through a suitable orifice in the form of a spray. Engines of this type, commonly known as the Brons or Hvid, may be started cold, though they lack flexibility from the viewpoint of speed, in comparison with the surface ignition type of engine.

In the solid injection of liquid fuel into an oil engine, one of three procedures in turn can be used. In the first, the oil is pumped to the fuel valves under sufficient pressure to effect vaporization, being subjected to combustion in measured quantities when the above valves are opened for admission; a separate plunger pump can be used for each cylinder, such a pump serving to meter out the requisite amount of fuel and deliver it at the necessary pressure; or, a central pump with a distributor can be used instead.

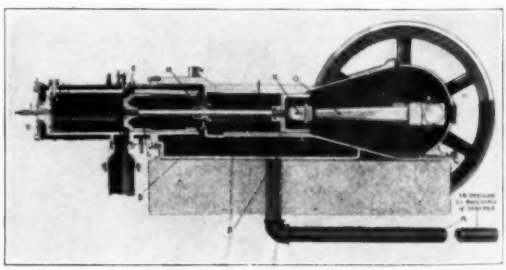
Essentially, whatever the means by which the fuel is delivered or ignited, the purpose in view is to so vaporize or atomize it and bring about such a mixture with the necessary air for combustion that it will be burned completely, with a minimum of residual matter such as carbon, soot and ash remaining in the cylinder. To attain this result, liquid fuel for use in an oil engine should be:

1. Of sufficient fluidity to enable pumping feasibly throughout the system without the necessity for preheating abnormally.

2. Free from bottom sediment or any other impurities which might clog the strainers, pump valves, fuel-injection valves, piping, nozzles or orifices according to the type of engine.

3. As free as possible from water inasmuch as this latter will not only tend to hamper ignition, but furthermore, it lowers the calorific value of the oil.

4. Of as low a sulphur content as possible, to avoid any chance formation of corrosive acids within the engine, particularly if water injection is used. Where fuel oils contain an abnormal percentage of sulphur, this latter may have an especially deleterious action on ball check valves, corroding the balls and causing leakage in certain instances, depending, of course, upon the extent to which the metal corrodes, the presence of moisture and the chemical form in which sulphur exists in the oil. In this connection it is important to remember that the successful operation of any oil engine will largely depend upon the efficiency of the fuel pumps and the completeness of atomiza-



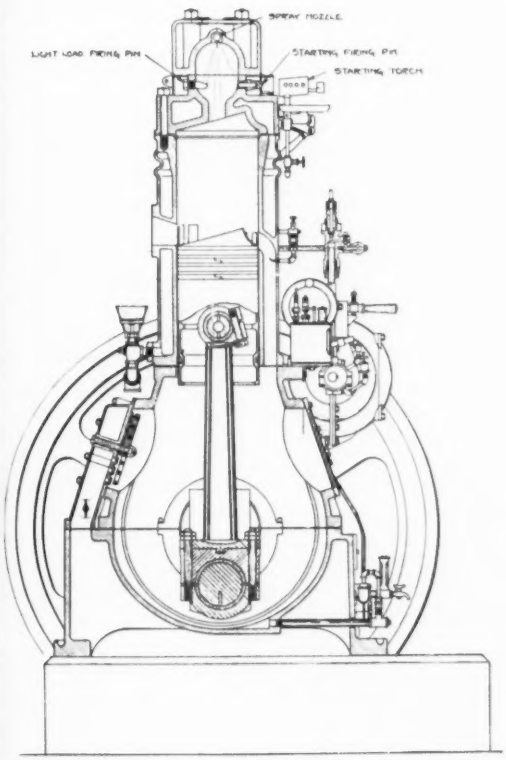
Courtesy of The Power Manufacturing Co.

Fig. 8.—A horizontal two-cycle oil engine showing simplicity of cylinder head and working parts. "A" is the air inlet pipe; "B" the warming and compression chamber; "D" the air valve; "E" the port for admitting scavenging air; "F" the exhaust port; "H" the heat compensator; "J" the hot plug; "I" the spray nozzle.

In this engine the main journal bearings are chain oiled; the other external bearings being splash lubricated. Cylinders are commonly served by mechanical force feed lubrication.

tion of the oil. The two-cycle engine, however, as a rule, can use a fuel oil with more sulphur in it than any other type of oil engine due to the general absence of exhaust valves.

5. Refined to a sufficient extent to bring about the removal of highly volatile hydrocarbon fractions which, under the ordinary conditions of storage and handling might vaporize and render the fuel unduly hazardous due to the generation of inflammable mixtures with air.



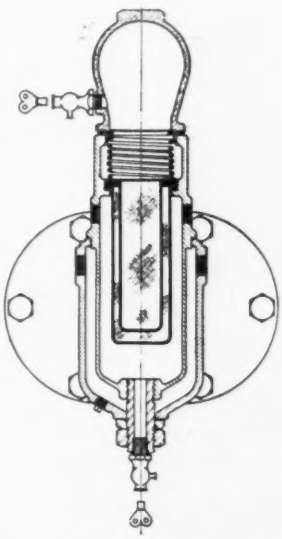
Courtesy of Anderson Foundry & Machine Co.

Fig. 9.—Sectional view of a vertical type of two-cycle oil engine, showing in particular the firing devices, such as starting torch, spray nozzle, etc. Once in operation there is normally sufficient compression to ignite the charge without the aid of any red hot surface.

For certain of the above reasons the use of heavier grades of bunker or boiler fuel oils is not recommended for some types of two-cycle engines. Of course it is perfectly possible to so blend these products with light distillates such as gas oils or kerosene to reduce their viscosity. On the other hand, especially in surface ignition engines, there will result a certain amount of carbonization which will ultimately reduce their power. The continued use of heavier grades of fuel oil will make it necessary to clean the combustion chambers or ignition surfaces at very frequent intervals due to the carbonaceous deposits which will accumulate with the breaking down and combustion of such oils. Pistons, in turn, will also require regular cleaning in event of the use of heavier fuels, though not as frequently as the combustion chambers. For this purpose, a brass scraper will be found more suitable than emery or other abrasives unless scoring has occurred abnormally.

To obviate the necessity for the above and derive the maximum of power from an oil engine it is evident that every effort should be made to obtain a fuel oil as free as possible from ash, sulphur and other residual matter. In many cases, this will mean the rejection of heavier fuel oils or crudes having a Beaume gravity below approximately 20 degrees. This will all depend on the design and construction of the engine. Some builders claim to have so perfected their method of combustion that even heavy Mexican or California crude oils can be satisfactorily burned. In general, however, the lower the proportion of residual matter or coke, upon distillation, the better will be the oil for Diesel engine purposes. A maximum of 5.0% is quoted by "Power" as the usual upper limit for all oil engines.

Then as to the matter of ash—this component is detrimental owing to its abrasive nature and the excessive wear which it frequently causes on the cylinder walls, etc. Ash usually consists of mineral matter such as iron and aluminum oxides, quartz and other silicates, which being in finely pulverized condition become mixed and retained by the lubricating oil films. The presence of such foreign matter on a cylinder wall, or in fact on any other wearing surface is so conducive to accumulation and abrasion, that authorities feel that an ash content above 0.05% is practically prohibitive in an oil engine fuel.

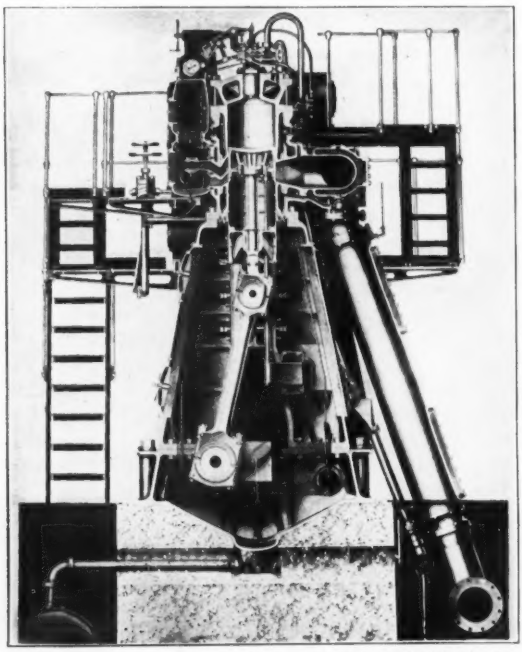


Courtesy of The Bessemer Gas Engine Co.

Fig. 10.—Section through a typical fuel oil strainer as used in oil engine service. Note that there are two strainers, one fine and one coarse. It is extremely important to properly strain all oil engine fuel, as brought out in the text of the accompanying article.

Sulphur in turn has been discussed heretofore in regard to its potential corrosive tendencies when in contact with moisture. Fuel

oils containing as high as 5.0% are claimed to be satisfactory by certain authorities, but where such are used, cast iron exhaust pipes should be installed, and every precaution taken to avoid presence of water vapor from chemical reactions, or otherwise, due to the resultant corrosive acids which would be formed.



Courtesy of Busch-Sulzer Bros. Diesel Engine Co.

Fig. 11.—A vertical, two-cycle Diesel type of oil engine, which is designed for pressure lubrication throughout. As a result all main bearings, crank pin and cross head pin bearings, crossheads, thrust bearings, etc., receive a continuous supply of cool, clean oil at all times. Oil is filtered after each circulation.

THE LUBRICANTS AND THEIR APPLICATION

While the fuel is essentially the factor which makes the oil engine run, the lubricants, in turn are the necessary means which must be used to keep it running. But just keeping running is not enough. Unless our engine develops a maximum of power with a minimum of fuel consumption, a flagrant waste is occurring which should be corrected. Therefore, lubrication and its relation to the development of power requires careful attention.

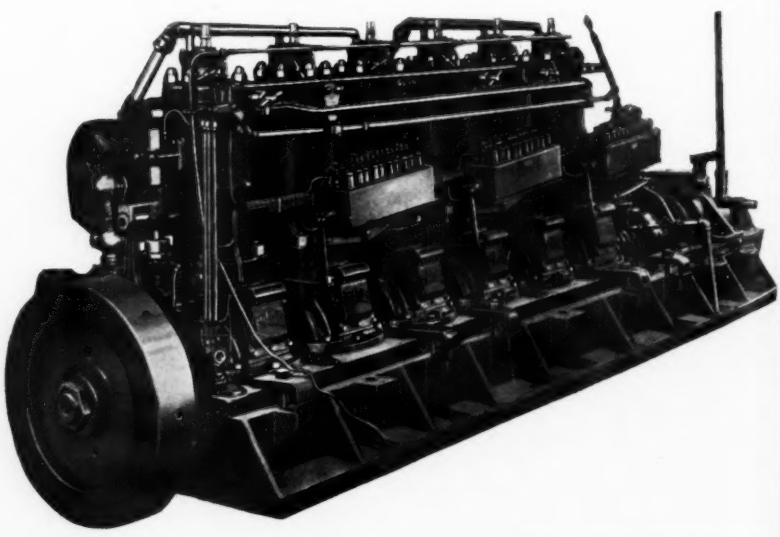
Regardless of whether a lubricant is to serve the engine cylinders or is to be used on bearings, it must possess a number of basic characteristics, viz.:

1. It must be so carefully refined as to be able to withstand the usual stresses and strains of intensive service. Also it should be carefully fractionated or the lighter components so effectively removed that it will not be so volatile as to require an undue quantity to maintain a suitable lubricating film especially on the cylinder walls.

2. It must be suited to the engine and also to the lubricating system installed; for we can readily appreciate that an oil might easily be an excellent product, yet refined in such a manner as to be absolutely unsuitable for Diesel engine service. A typical example would be a steam cylinder lubricant.

3. Furthermore, it must be of such a viscosity or body as to maintain a lubricating film of suitable thickness between the wearing surfaces. Yet it should never be so heavy or viscous at the usual temperatures of operation as to give rise to abnormal internal friction within itself, for this might readily develop excessive operating temperatures especially on the engine bearings.

4. It should be sufficiently adhesive to resist being squeezed out from between the wearing surfaces when subjected to the normal pressures of operation.

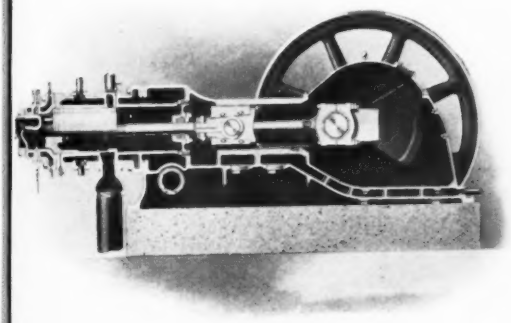


Courtesy of Mianus Diesel Engine Co.

Fig. 12.—View of an horizontal, two-cycle oil engine which is in turn oiled by mechanical force feed lubricators. Note the three lubricators, in this case, adjacent to the engine.

5. It should not congeal at any of the lower temperatures to which it might be subjected during storage or operation.

6. It should be capable of spreading readily over the wearing surfaces in the case of cylinder walls, not remaining in streaks or blotches for otherwise suitable sealing of the pistons might be impaired.



Courtesy of The Bessemer Gas Engine Co.

Fig. 13.—An horizontal two-cycle engine in which air is received through a port independent of the crank-case. Thereby there is no possibility of oil in the crank-case being vaporized and lost.

7. It should have as low an emulsification tendency as possible due to the contact with water which may often occur.

8. It must have as low a carbon residue, or tar-forming tendency, as possible, inasmuch as the decomposition which will occur when the oil is exposed to the intensive heat of combustion, will develop a carbonaceous residuum. Furthermore, this latter should be capable of easy removal.

It is fully appreciated that for an oil to meet all the above requirements the most careful attention is necessary not only in refining, but also in transportation, storage and handling in the plant. In fact certain of the above cited characteristics are practically conflicting, therefore the very best judgment is necessary in the selection of the ultimate oil, taking into account of course those requirements which in the particular case are most desired. Yet the two-cycle engine is not difficult to lubricate properly, if it has been carefully designed. In fact the cylinders are the only parts requiring more than usual attention from a lubricating point of view, due to the fact that:

(a) The oil is subjected to high temperatures at more frequent intervals over each cycle; and

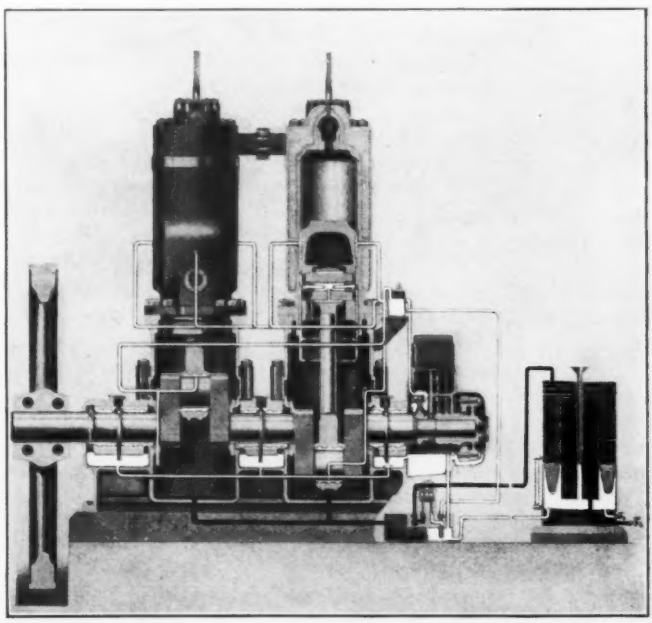
(b) The high velocity of the gases of combustion at the exhaust ports increases the vaporization of the lubricant in this region of the cylinder.

In order to reduce this vaporization an oil of lower volatility could be used but this would mean that probably a higher carbonaceous residue would accrue, and also that an oil of higher pour test would have to be selected.

Application of Cylinder Lubricants

Quite as important as the grade of oil used for cylinder lubrication is the method and rate of application. The oil should be so fed as to impinge directly onto the pistons, the time and point of application being so planned that the charge will strike between the first and second rings (from the top) when the piston is at the lowermost point of its stroke. This is most important inasmuch as were the oil to miss the piston or be admitted at a time when the latter did not cover the point of oil discharge, a certain amount of lubricant would be lost, necessitating increased feeding and ultimately leading to carbonization. In fact successful oil engine cylinder lubrication is dependent upon four factors, i. e.:

(a) The use of properly refined oil;



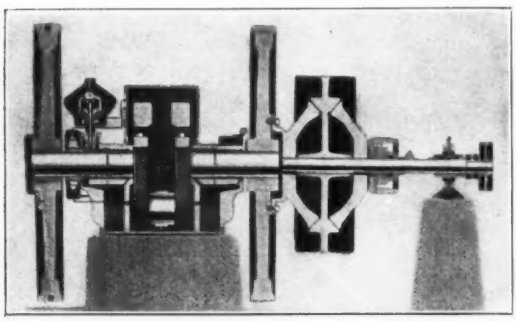
Courtesy of Fairbanks, Morse & Co.

Fig. 14.—A two-cycle oil engine lubricating system which is entirely automatic. The mechanical lubricator, sump pump and outside filter with their respective oil piping, are all clearly shown. Black lines indicate used oil; white indicate clean oil; and also the oil level in the respective wells. Note that main bearings are ring oiled, their oil wells being connected to the main lubricating system. In this engine one grade of lubricant is used throughout. Cylinders are lubricated at three points each as shown.

(b) Application of sufficient though never excessive amounts;

(c) Delivery through oil ways so located that the piston and rings will receive the maximum of this charge;

(d) Application at exactly the right time.



Courtesy of The Power Manufacturing Co.

Fig. 15.—Sectional view of a single cylinder engine through the crank shaft and clutch pulley showing method of lubricating the governor and main journal bearings. Force feed is used on the former, the latter being chain oiled. The other external bearings are automatically lubricated by the splash system.

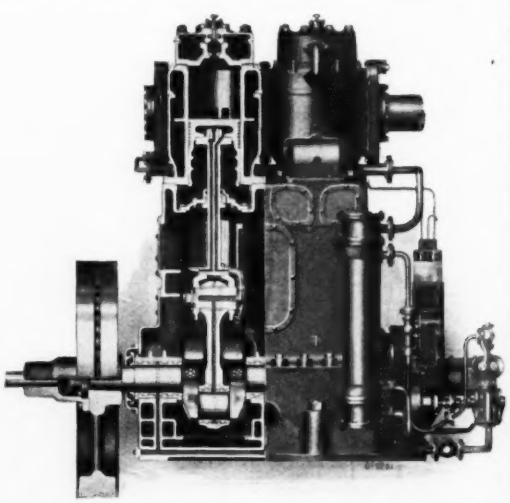
The number of points at which the lubricant should be applied to the piston of an oil engine will depend naturally upon the type and size of the engine; two to three oil holes equidistantly located in the cylinder wall will generally suffice, although this will of course depend upon the bore of the cylinder. Care should be taken that none of these oil holes are located in line vertically with the exhaust ports, otherwise the exhaust gases will tend to carry off a certain amount of lubricant. This, of course, would be a direct waste.

The effectiveness with which the lubricant will be distributed will also depend to a certain extent upon the fit of the piston rings. Loose rings will not only decrease this but also will allow blow-by to occur. The loss of compression and passage of hot gases which will result will naturally tend to cause overheating of the lower parts of the cylinder and piston, the oil film being either burned or dried up prematurely. Fortunately, however, there is not the same opportunity for dilution of the lubricating oil occurring as exists in the carburetor type of engine, due to the fact that the fuel charge is burned to practical completeness as fast as it enters the combustion chamber.

On the other hand where the rings are too tight a scraping action will be exerted over the cylinder walls, the lubricating film often being broken or at least dangerously reduced. To counteract this possibility certain authorities advise slight beveling of the upper edges of the top piston rings in order to facilitate their sliding over the oil film on the up stroke. Tight, improperly set rings may also lead to the pistons sticking, especially where the lubricating film is not perfect, where an excessive amount of oil has been supplied or in case imperfect combustion is occurring. With certain grades of oil an excess of this latter will develop gummy residues due to their lack of free-burning characteristics. While the engine is hot, naturally these residues will be relatively pliable, though in all probability extremely viscous. On shutting down, however, they will often congeal to such an extent as to practically seal or freeze the piston to the cylinder, rendering subsequent starting a difficult proposition.

Imperfect combustion requires detailed consideration due to the extent to which it affects fuel economy. In general the former is the result of low compression pressures caused either mechanically or by leaky rings, excessive overloads or insufficient air, (in other words the firing of too rich a mixture as we would say in automobile parlance). Where imperfect combustion is allowed to continue carbonization will practically always occur especially on the piston head and in all probability around the rings. Therefore, carbonization is often the parent of faulty valve action and stuck piston rings. In turn this latter occurrence will cause compression losses.

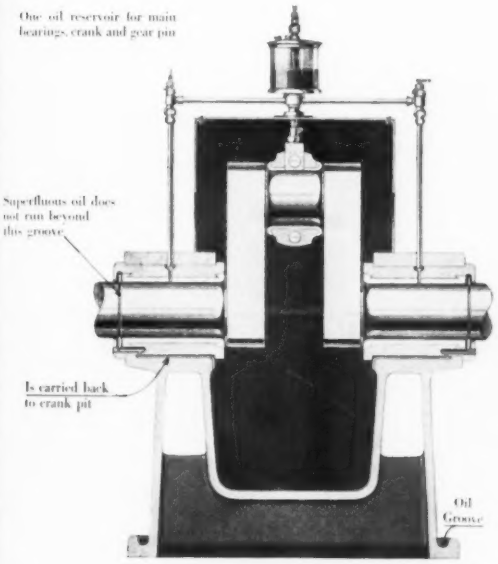
In consequence a complete cycle of inefficiency may result. Where rings are stuck in their grooves they must, therefore, be loosened as soon as possible. Oftentimes kerosene



Courtesy of Worthington Pump & Machinery Corp.

Fig. 16.—Longitudinal section of a vertical engine showing pistons directly oil cooled. In this engine the oil pump forms part of the engine. Note oil leads through connecting rod to piston for the purpose of cooling the latter. Lubricating oil is used for cooling the pistons, in that: (a) The same pump thereby serves for delivering both cooling and lubricating oil; (b) Closed pipes for discharging heated oil from the pistons are avoided; and (c) One cooler serves for both the lubricating and piston cooling oil.

or a lye-water mixture will serve this purpose, cutting the gummy matter effectively, in case merely scraping away the deposits is not sufficient.


One oil reservoir for main bearings, crank and gear pin
Superfluous oil does not run beyond this groove
Is carried back to crank pit
Oil Groove

Courtesy of Charter Gas Engine Co.

Fig. 17.—Section through main bearings of an oil engine showing details of construction and provision for lubrication. Path of oil in its course through the system is clearly shown.

Amount of Cylinder Oil Required

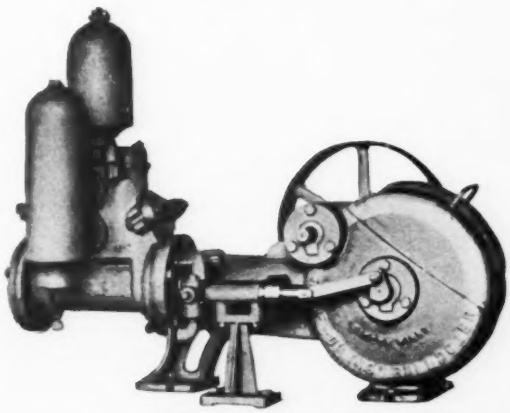
This brings up the question as to just what amount of oil should be used to lubricate the cylinders. Usually such factors as the grade and quality of the oil, the method of application, the number of oil feeds and the type and construction of the engine must be considered. In general, while certain figures (such as say, 10 to 20 drops per minute) could be quoted based on ideal operating conditions, it is safe to state that a certain amount of experimentation should always be carried out, for practically every oil will vary in its lubricating ability dependent upon its viscosity and manner of refinement. Where a mechanical force feed lubricator is used capable of feeding oil in synchronism with the strokes of the pistons, frequently it is possible to control the oil feed so accurately as to approximate the theoretical requirements of the engine for the particular oil in service.

With engines of the enclosed crankcase splash-oiled type, while cylinder lubrication is often carried out separately, a certain amount of this will be derived from the vaporous fog of lubricant which is present in the case during operation. Naturally this should justify a certain amount of reduction in oil feed to the cylinders themselves. The extent to which secondary cylinder lubrication of this nature is brought about, however, is not measurable with any accuracy; therefore the amount to which cylinder lubrication could be reduced cannot be definitely stated. It must be remembered that wherever the crankcase serves also as an air compressor, lubrication of the two-stroke cycle, splash-oiled engine has a potential tendency of requiring more oil in general than a four-cycle engine. Essentially this is due to the possibility of oil being blown out while in vaporous form during the scavenging period.

Bearing Lubrication

Other pertinent bearing parts of the two-stroke cycle oil engine which require careful lubrication are the wrist pins, the crank pins, main bearings and crosshead guides. With the possible exception of the wrist pins which are contained in an enclosed position and subjected to considerable unradiated heat, the above parts will in general involve no difficult lubricating problems. Pressures are usually high, clearances low and operating speeds above the average in steam practice; yet the circulating force feed oiling system, the mechanical lubricator, or the principles of splash lubrication (in the enclosed crankcase engine) are all readily adaptable.

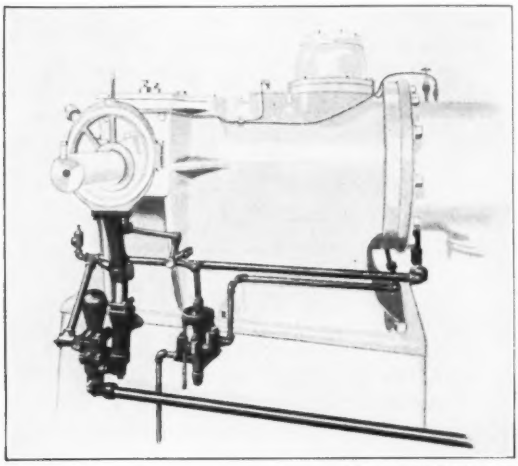
On large engines the first is preferred by many authorities. In effect it is probably the most dependable system in that it furnishes a continuous stream of oil to all the bearing parts in question and is capable of being put in series with a filtration or purification system which will insure the delivery of practically pure oil, thus eliminating the possibility of clogged oil ways. Furthermore,



Courtesy of Anderson Foundry & Machine Co.

Fig. 18.—A combined water circulating pump and auxiliary fuel pump for oil engine service. Both are of the double acting, back-geared, slow running plunger type. Where water must be lifted by suction, this type of pump is recommended by the manufacturers.

the oil feed to each part, in certain cases, can be independently controlled. On the other hand, it may be too costly to install and too intricate commensurate with the size of some engines. Perhaps this is why the mechanical force feed oiler is so extensively used in its place, especially on smaller engines. With this device it is possible to use the same lubricator for both cylinder and bearing lubrication, by keeping the requisite lubricants in separate compartments. There is, however, always a possibility of the oils being mixed up and for this reason many authorities insist that separate lubricators be used. Of course, where the engine is so designed that its cylinders and bearings are capable of being served by the same lubricant, one such lubricator will be found to function admirably.



Courtesy of Muncie Oil Engine Co.

Fig. 19.—Method of driving an oil engine water circulating pump and auxiliary fuel lift pump. The pump used for this purpose is an eccentric driven plunger type with independent suction and delivery valve chambers; bronze disc-shaped valves with rubber seats and bumpers are used, over which are removable cover plates giving ready access within.

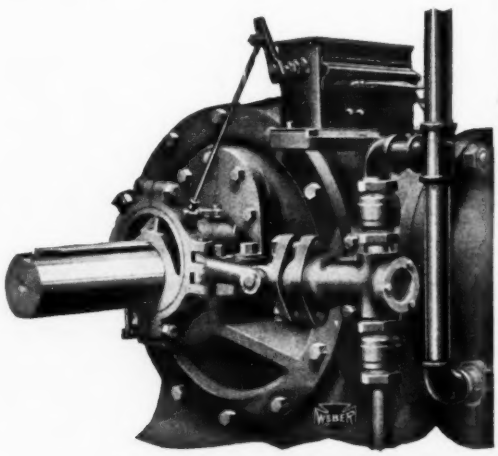
COOLING THE ENGINE

As stated earlier in this article, cooling water and the extent to which it effects reductions in cylinder temperatures is one of the cardinal operating factors which must be given careful consideration. Abnormally high cylinder temperatures are a detriment to efficient operation in that they are a hindrance to effective combustion and lubrication, causing cracking, abnormal carbonization, burning, gumming, and compression losses, with the resultant necessity for increased oil supply. In other words, the power developed per gallon of fuel and lubricating oil will be decreased. Furthermore, deposits around the piston rings, on the valves, seats, or elsewhere in the combustion chamber ultimately require tearing down of the engine for cleaning, consequently costs of upkeep rise in proportion.

Therefore temperatures in excess of those required for efficient combustion must be avoided. In general they will be caused by overloading the engine, improperly designed cooling systems, the use of too little cooling water, obstructions in the water pipes, jackets and waterways of the engine, improperly adjusted fuel spray valves, or poor scavenging. The ideal cooling system should be capable of delivering the requisite amount of water commensurate with the load on the engine and the volatility of the fuel. Volatility is decidedly important inasmuch as under lighter loads the cylinder temperatures may be somewhat lower, even though the flame temperature remains approximately the same. Consequently, if a fuel oil incapable of complete gasification at such temperatures is used, naturally a certain amount of unvaporized residue will remain after firing, to promote cylinder deposits much as an imperfect lubricating oil would do.

Types of Cooling Systems

Diesel engine cooling systems may be broadly grouped into two general classifications, dependent upon whether the discharge is open or closed. In the first or open type, water circulation is visible to the operator as the discharge from the engine flows into the sump preparatory to cooling. This is preferred by many authorities over the method of pumping the water directly to and from the cooling medium.



Courtesy of Oil Well Supply Co. and Weber Engine Co.

Fig. 20.—Another type of water circulating pump, which is attached to the side of the engine, being operated by means of an eccentric from the crank shaft. This installation is claimed to eliminate certain of the troubles which may occur with detached water pumps.

Grade of Water

The grade of water is also quite an important factor. So-called hard waters, or those high in carbonates and sulphates of lime or magnesia, etc., are not advisable for extensive

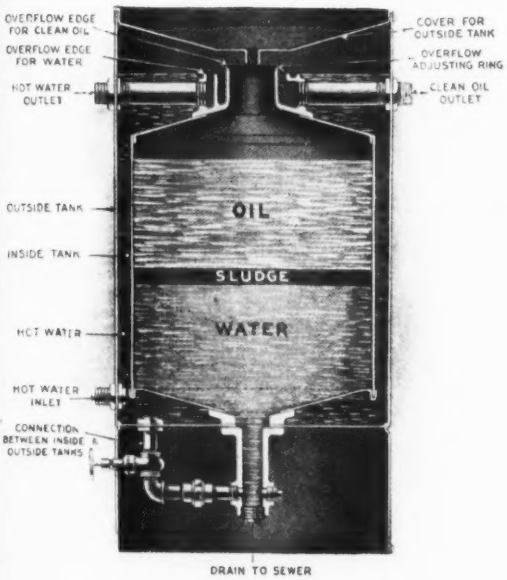


Fig. 1. Sectional View.

Courtesy of De La Vergne Machine Co.

Fig. 21.—Sectional view of an oil reclaimer wherein the dirty oil is subjected to brief but violent agitation with a solution of hot water and a special coagulant. The effect brought about is claimed to be purely mechanical, being based on the scientific principle of relative surface tensions of oil and water.

usage unless properly softened, due to the hard deposits and encrustations which usually accumulate within the engine cooling jackets. Use of hard water can also be eliminated by installing a softening plant, or, enclosing the cooling system and using soft water entirely, cooling it sufficiently after each circulation by means of some approved type of condenser or cooling tower. Both methods involve an initial expense which may often seem to be out of proportion, but over the long run they will pay for themselves in engine efficiency and fuel and lubricating economies; they are especially adaptable to larger types of engines.

Amount of Cooling Water Required

In order to maintain a flow of cooling water through an oil engine such that the discharge temperature will be in the neighborhood of 140 to 150 deg. Fahr., a certain amount will have to be circulated dependent upon the inlet and outlet temperatures, the extent to which heat transfer takes place and the amount of heat given up by the fuel to the engine. Certain very helpful data are given by "Power" as brought out by the following formula for the determination of the theoretical amount of cooling water required, viz.:

$$W = \frac{XH}{100\ (T_1 - T_2)}$$

When

X = percent of heat in cylinder absorbed by the water;
H = heat of the oil to the engine;
T_1 = discharge water temperature;
T_2 = inlet water temperature;
W = weight of water per hp. hour.

Since usually $\frac{XH}{100}$ approximately equals 3000 B. t. u. per horsepower hour, the formula can be written

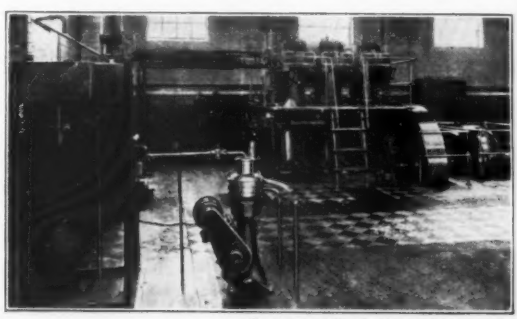
$$W = \frac{3000}{T_1 - T_2}$$

In case of a 500 horsepower engine

$$W = \frac{500 \times 3000}{120 - 80} = 37500$$

or 75 lb. per horsepower hour.

In this connection it is of further interest to know that normally from 8 to 10 gallons of water per brake horsepower hour is required for suitable engine cooling under average operating conditions. This is of course providing that the discharge line is so vented as to eliminate any possibility of the development of steam pockets, to the ultimate danger of the water jackets.



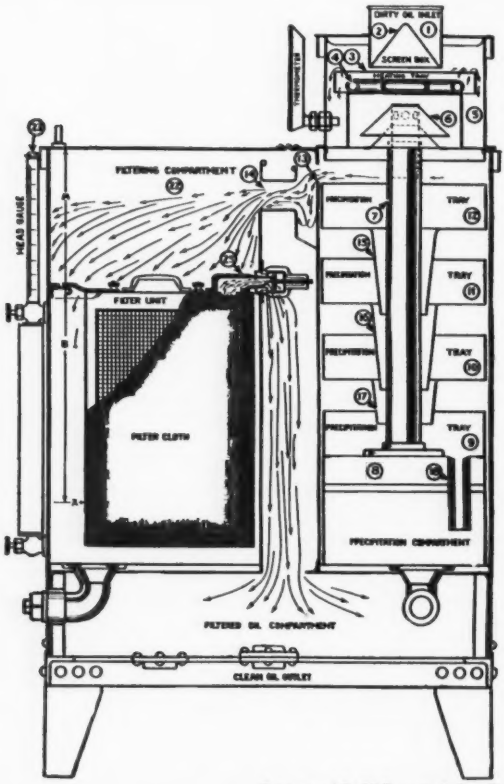
Courtesy of the De Laval Separator Co.

Fig. 22.—An oil engine installation showing an oil purifier of the centrifugal type installed for separating out water and foreign matter from the used oil. The compactness of such a system and its relative size in comparison with an average engine is clearly shown. Note the necessary tanks, drains and piping adjacent to the purifier. This device employs the action of centrifugal force to bring about the necessary separation of the heavier suspended foreign matter from the oil.

OIL PURIFICATION

Quite as important as the proper selection of lubricants for the two-cycle oil engine is the matter of their purification during operation. Especially is this true where the engine is

built with an enclosed crankcase, pressure lubrication being employed on the various bearings. Sediment will accumulate, and water of condensation is always a possibility; also leakage from the cooling system may develop to further contaminate the oil. Emulsification



Courtesy of S. F. Bowser & Co., Inc.

Fig. 23.—Details of a modern oil filter. In this device dirty oil enters at the top, passing first through a removable strainer box where larger particles of foreign matter are removed. It then passes over heating coils to reduce its viscosity and enable the more ready separation from water. This latter is brought about by then passing the oil upward over a series of staggered precipitation trays. From here it is led to the filtration compartment, where any remaining foreign matter is removed. The course of the oil in passing through these several stages can be readily followed.

and sludging will be the natural sequences if oils so contaminated are continued in service, clogged oil ways and bearing troubles being the culmination. The presence of iron oxides, such as rust, cause an increase in the rate at which all this may occur; especially will they hamper the separation of water from the oil; therefore, the oil in service must be kept clean for it must not only lubricate effectively in order to reduce wear, but also it must be capable of protecting the wearing surfaces against rust or corrosion when the engine is shut down.

Carbon, which is another prevalent contaminating agent, is also a sludge creator, tending, in addition, to impair proper lubrication even when held in free suspension in the oil. Furthermore, this suspension of minute particles of carbon is claimed to render the problem of purification considerably more complex than it normally is in steam power plant service. In general such carbon will not settle out readily from the oil, rendering simple gravity separation a difficult matter. Filtration, centrifugal action, or agitation in presence of a coagulent capable of throwing down the carbon, however, are all effective methods of purification.

In addition these systems serve to remove water and other contaminating foreign matter. It must be borne in mind, however, that a certain amount of loss will accrue which must be taken care of by the periodic addition of a suitable amount of new or purified make-up oil.

Impure air in plants where dusty materials or products are being handled is also the frequent source of foreign matter, which as it usually consists of siliceous particles, has a decided scoring or abrasive ability. Of course, the oil purifier will remove such matter, but it is better to remove it at the source by using some filtering medium at the intake.

CONCLUSION

In the foregoing article effort has been made to bring out the fact that lubrication is the salient feature involved in the attainment of successful, economical oil engine operation. While discussion has been limited to the two-cycle engine, we can readily appreciate that the four-cycle engine is certainly a worthy subject for similar consideration. It will, therefore, be taken up in detail in a later issue of LUBRICATION.

In closing it is well to state that many engineers, especially those who have to deal with the smaller industrial types of two-cycle oil engines, have gained the impression that lubrication is unimportant, inasmuch as their machines often operate successfully under conditions considered detrimental thereto. This, of course, is decidedly the wrong viewpoint. Perhaps it has been fostered to a certain extent by virtue of the wide variety of lubricants on the market. In this regard we must realize the difficult task with which the oil refiner is confronted. Engine design, the type of lubricating system, mode of operation, constructional features and the conditions which the lubricants must meet, all require consideration. The essential point is to select lubricants which have been properly and carefully refined by reputable oil companies for the purposes intended. A progressive operator today fully realizes how this will insure against breakdowns and the possibility of serious damage to valuable equipment.

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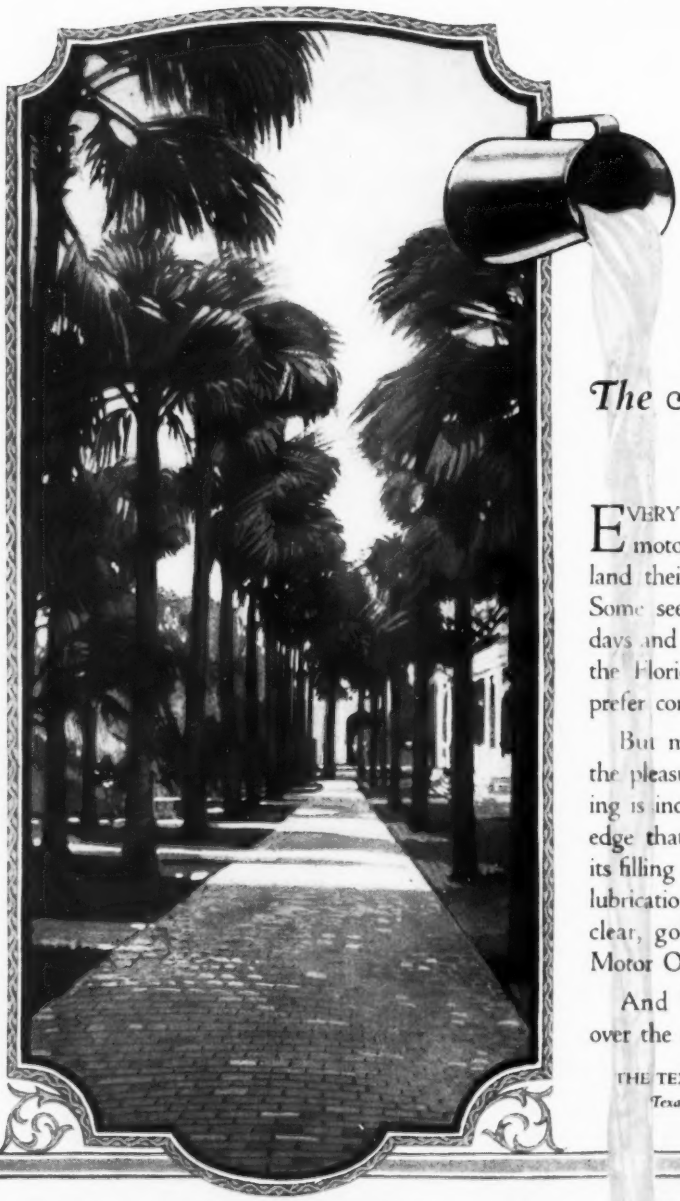

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